



Australian Government Initiative

WATER QUALITY
AUSTRALIA

Improving water quality

Stories of progress and success from
across Australia

2012

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with state and territory governments.

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Preface

One of the challenges in improving our waterways and catchments is the sharing of knowledge. With many daily and longer-term demands, it can be hard to find the time to share useful information and the lessons learned.

The 12 case studies in this book reflect the diversity of our continent. They exemplify what can be done when leadership, teamwork, continuing commitment and appropriate resources come together to support delivery of the National Water Quality Management Strategy (NWQMS). They highlight the importance of embracing the key NWQMS guidelines and taking approaches that are suited to local environments, competencies and circumstances when seeking to improve water quality or ecosystem health.

In selecting and presenting these particular case studies, the many other outstanding water quality management initiatives across Australia are acknowledged along with the key people whose work and success could be similarly shared and celebrated.

The efforts of the key people are acknowledged as making this book possible. Their stories of success are testimony to what has been achieved and can still be done to improve the health of our rivers, estuaries, coastal waterways and their catchments.

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1 The National Water Quality Management Strategy

The reduction in environmental health of some of Australia's iconic water bodies, such as the Murray–Darling river system, bears testimony to the need to protect and enhance the quality of water in our rivers, estuaries, lakes and other water bodies. In recognition of the need to better manage the quality of our water resources, the Australian Government, in cooperation with state and territory governments, have jointly implemented the National Water Quality Management Strategy (NWQMS) since 1992. The NWQMS aims to protect the nation's water resources by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development. The NWQMS consists of three major elements:

- policy
- process
- guidelines.

1.1 Policy

The main policy objective of the NWQMS is to achieve sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development.

1.2 Process

The process for water quality management to achieve the policy objective starts with the community working in concert with government to identify and agree to waterway environmental values to be protected or restored. The NWQMS further recommends the development and implementation of a water quality management plan for each catchment, aquifer, estuary, coastal water or other water body.

Environmental values are particular values or uses of the environment that are important for a healthy aquatic ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. Six environmental values are recognised in the NWQMS:

- aquatic ecosystems
- primary industries
- recreation and aesthetics
- drinking water
- industrial water
- cultural and spiritual values.

The plan should take account of all existing and proposed activities and developments; identify water quality targets; and contain feasible and cost-effective management options that aim to meet the water quality targets and hence achieve the environmental values for that water body.

The NWQMS envisages use of both regulatory and market-based approaches. Management of water quality is largely a state and territory responsibility, but implementation of the NWQMS is done in the context of:

- state and territory water policies
- the NWQMS national guidelines.

1.3 National guidelines

The national guidelines are technical papers providing nationally agreed guidance on many aspects of the water cycle, including ambient and drinking water quality, recreational water management, monitoring and reporting, groundwater protection, rural land and water issues, urban stormwater, sewerage systems, effluent management for specific industries and water recycling. The NWQMS guidelines are not mandatory and provide guidance to governments and communities on the sustainable management of the nation's water resources. The full set of NWQMS documents is available on the [NWQMS website](#).

2 Goulburn Broken Water Quality Strategy review

Table 1 Goulburn Broken Water Quality Strategy review—summary

NWQMS focus:	Strategy review and adaptive management
Lead organisation:	Goulburn Broken Catchment Management Authority
Contact:	03 5820 1100
Partner organisations:	Goulburn Murray Water, Goulburn Valley Water, North East Water, DPI, DSE, Environment Protection Authority (Victorian Government) and local government

2.1 Place

The Goulburn Broken Catchment is located in Northern Victoria in the southern Murray–Darling Basin. The aquatic ecosystems of this catchment are highly valued by locals and visitors alike. They are important in terms of their National Water Quality Management Strategy (NWQMS) environmental values, including for habitat, recreation and aesthetics, urban water supply and primary industries (irrigation, industry and stock water supply).

2.2 Challenge

The initial challenge arose with the extensive algal blooms in the Murray–Darling Basin in the 1990s and the ensuing high-level publicity and public concern. During the 1990s the Goulburn Broken Catchment was considered Victoria’s highest priority for nutrient reduction, as high nutrient loads were a key driver of algal blooms. The Goulburn Broken Catchment Management Authority (CMA) released the Goulburn Broken Water Quality Strategy (the Strategy) in 1996, with a specific focus on reducing total phosphorus loads of catchments by 65 per cent over 20 years. The Strategy had specific programmes to address phosphorus loads in each of the major land use / industry areas: irrigation drainage, dryland, wastewater management facilities, urban stormwater, intensive animal industries and local water quality issues.

Since the release of the Strategy, monitoring results have shown declining trends in phosphorus exports. A review of the Strategy was undertaken in 2003, but a substantial challenge arose in 2005 with the release of the Victorian Regional River Health Strategies. The Victorian Regional River Health Strategies highlighted a need to take a broader-based and more integrated approach, so the Goulburn Broken Regional River Health Strategy attempted to combine all elements of river management, including water quality, under one umbrella. This proved to be a challenging process.

2.3 Response

In 2007, facing these challenges and a forthcoming review of the Goulburn Broken Regional River Health Strategy, the Goulburn Broken CMA determined that they would conduct a ‘whole-of-programme’ review of the Strategy. Rather than just consider the programmes, their implementation and effectiveness, the CMA decided to extend the review process to re-evaluate the assumptions that had been made originally and the water quality parameters of interest in light of their new strategies and new knowledge.

2.4 Results

The revised Strategy is quite different and a significant advancement on the original one developed in 1996. However, this does not diminish in any way the earlier foundational work but reflects current conditions, experience and knowledge.

The new strategy was informed by a range of NWQMS processes; and updated information has been derived from monitoring, integration across programmes and agencies, coordination and community involvement. Looking beyond the local and regional catchment boundaries and continuing to learn from others has also been pivotal to success.

The review of the Strategy resulted in some high-level findings:

- the focus on phosphorus should be retained, but there needed to be an increased emphasis on both nitrogen and flow management consistent with the more integrated approach
- implementation of best management practices should be continued, as it was still regarded as the principal and best means to achieve strategy objectives
- existing water quality strategy programmes should continue, especially in relation to river health and irrigation
- while there was generally good coordination within individual programmes and established networks across government agencies, coordination mechanisms for the Strategy as a whole could be better developed.

The success of the Strategy in reducing total phosphorus levels is shown in Figure 1, which clearly demonstrates substantial additional reductions in 2007 from 1994 levels—well beyond those that were expected to arise from strategy implementation.

The review identified many additional issues with implications for water quality at both a local and a catchment scale. These issues were ranked according to the risk that they presented. This enabled the top-priority issues to be identified and addressed as part of the revised Strategy.

At the individual programme level, progress varied dramatically. Some of the major successes included:

- progress in water use efficiency through irrigation and drainage programmes which significantly reduced drain flows, reducing total phosphorus and nitrogen levels
- dramatic improvements in water quality from upgrades of wastewater management facilities, with 2007 loads reduced to just 2 per cent of 1994 loads
- improvements in the management of waterway incidents through improved coordination and local operations
- Waterwatch programs maintaining strong stakeholder engagement
- many knowledge gaps being filled through local research and investigations as well as by transferring results from elsewhere.

As well as the successes, the review identified the following areas still requiring attention:

- uncertainty around the progress of water quality in intensive animal industries
- prioritisation of investigations and support in the dryland farming programme, especially with regard to options for achieving the most benefit from investment

- septic tanks continued to present a water quality issue at a local level, along with stormwater management from existing urban areas.

2.5 Benefits

The review has assisted the region to substantially improve water quality management, especially with a number of initiatives having been completed. These included reviewing State Environment Protection Policy (SEPP) triggers, identifying priorities for ecological risk assessments and assessing the potential impacts of climate change.

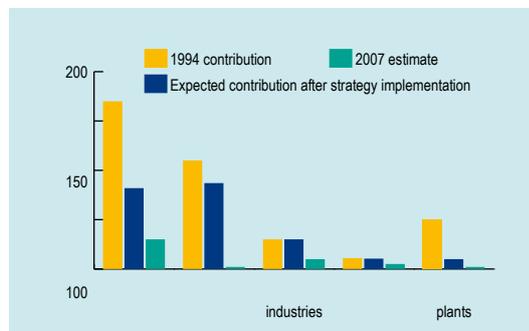
The comprehensive nature of the review also enabled alignment with broader ecosystem and river health strategies and captured knowledge at a catchment and basin level; and renewed stakeholder involvement and engagement in water quality management.

2.6 Lessons learned

There are several valuable lessons to be learned from the Strategy review that are transferable throughout Australia. While an overarching strategy provides essential direction and focus, it is important to adjust approaches in the light of new knowledge and information.

There is a need to continually improve efforts in water quality management through the adaptive management cycle which is a key part of the NWQMS: planning, implementing, monitoring, evaluation and improvement. The Adaptive Environmental Assessment and Management (AEAM) process used by the Goulburn Broken Catchment has been invaluable.

Figure 1 Total phosphorus contributions—1994, 2007 and expected



3 Developing environmental values for Botany Bay

Table 2 Botany Bay environmental values—summary

NWQMS focus:	Stakeholder engagement and environmental values
Lead organisation:	Sydney Metropolitan Catchment Management Authority
Contact:	02 9895 7898
Partner organisation:	Australian Government Department of Sustainability, Environment, Water, Population and Communities

3.1 Place

Botany Bay is an international port located a few kilometres south of the city of Sydney. The Cooks and Georges Rivers are the two major tributaries that flow into the bay.

Botany Bay has a unique marine life and supports a wide variety of uses, including recreation, boating, recreational fishing, marine transportation and industry.

3.2 Challenge

Pollutants pose a significant threat to the environmental values (EVs) of the surface waters of Botany Bay. Consistent with the National Water Quality Management Strategy (NWQMS), the Botany Bay Water Quality Improvement Program seeks to achieve long-term protection of the surface waters of the bay, its estuaries and the catchment. In order to achieve this, the programme focused on key pollutants, including suspended solids, nitrogen and phosphorus, and combined this with two critical and diverse components of the NWQMS:

- *science*—to model the ecological response to changes in catchment condition for Botany Bay and its estuaries
- *stakeholder engagement*—to involve councils and other key stakeholders in a participatory process to identify and implement innovative solutions to improve water quality.

3.3 Response

To be able to act effectively for the long-term protection of the waters of Botany Bay, it was necessary to develop a greater understanding of the system and identify what was important to the community as well as management goals and actions. Achieving this required a number of key steps. So far, these have included:

- mapping the catchment and sub-catchment areas
- developing levels of protection for the EVs of Botany Bay and its catchment waterways
- modelling current contributions of nutrients and sediments in the catchment
- understanding the ecological response of the system to key pollutants and how much the system can receive before irreversible ecological change occurs
- developing water quality objectives (WQOs) and load targets required to protect the environmental objectives

- identifying management options to improve water quality and ways to overcome barriers to implementation
- reviewing statutory and institutional arrangements that relate to protecting water quality in Botany Bay
- developing a Water Quality Decision Support System for use by councils and catchment managers.

The EVs and WQOs component of the programme involved a series of 18 workshops held around the catchment. A total of 140 participants from councils, the community and government departments were involved. Major activities focused on a questionnaire on EVs, setting draft levels for EV protection, and developing WQOs and management goals for each of the sub-catchments. The questionnaire sought to identify the views of people about their waterways and to capture what they most appreciated about them; what they would like to do in future; what they were most concerned about losing; what they saw as the key threats; and what ideas they had for better management.

The catchment was subdivided into 16 sub-catchments that were further subdivided into a total of 26 sub-areas (for example, individual creeks and upper and lower reaches of creeks) for the purposes of the workshops. Workshop attendees used a standardised template to assist in identifying draft levels of ecosystem protection, WQOs and management goals.

3.4 Results

The questionnaire on EVs received almost 100 responses. Approximately half were from local government and over one-third were from the community. The top five concerns of the respondents for waterways in the region were water quality, loss of native vegetation, loss of biodiversity, reduction of native wildlife and loss of scenic beauty and amenity.

The key threats identified from the survey were sewerage systems and sewage overflows, littering, run-off from industry and urban development, and chemical impacts. The questionnaire found that in the future people would like to use their waterways for swimming and recreation and adjacent areas for bushwalking and walking. To achieve the goal of using waterways for swimming, water quality will need to be improved to meet the NWQMS trigger values for primary contact.

The workshop clarified the desired future direction for enhancing the environment of this area. In most cases, responses were grouped around the required course of action. Actions related to:

- *levels of ecosystem protection*—12 sub-catchments were identified as having a high conservation or ecological value, two as being highly disturbed and 11 as being slightly or moderately disturbed
- *water that met the NWQMS trigger values for primary contact activities*—this was the preferred level of EV to be achieved or protected in 15 sub-catchments. Secondary contact was the preferred level in 10 sub-catchments, and for one sub-catchment responses were evenly split between wanting to achieve suitable water quality for primary and secondary contact
- *achieving water quality suitable for drinking*—this was strongly supported in six of the sub-catchments.

Management goals for the 26 sub-catchments under consideration were identified as follows:

- *protect natural condition*—eight sub-catchments

- *restore to near natural condition*—four sub-catchments
- *restore to modified healthy condition*—nine sub-catchments
- *rehabilitate key elements of system*—two sub-catchments
- *clear preferences for a management objective was not identified*—three sub-catchments.

3.5 Benefits

The Botany Bay Water Quality Improvement Program has successfully engaged councils, other key stakeholders and the general community in catchment and water quality management. This has resulted in more innovative solutions to improve water quality in the bay and its catchment. The process has provided clear directions for future management objectives and actions that have a greater level of agency and community ownership due to the direct participation that went into their development.

3.6 Lessons learned

The comprehensive approach taken to managing water quality under the Botany Bay Water Quality Improvement Program is highly suitable for transferring to other areas throughout Australia. As demonstrated by the Botany Bay experience, key elements of the NWQMS can be successfully implemented with good planning and well-executed delivery of participation processes even in very complex catchments exhibiting environmental, social, economic and cultural diversity. A water quality improvement plan has now been developed, providing a framework that engages all key stakeholders and other interested community members. The work to date has provided a sound basis for all sectors to continue involvement in water quality management. For more information visit [the New South Wales Government Local Land Services website](#).

4 South-east Queensland capacity building trial

Table 3 South-east Queensland capacity building trial—summary

NWQMS focus:	Community engagement, partnerships and water quality monitoring
Lead organisation:	South East Queensland (SEQ) Catchments
Contact:	07 3211 4404
Partner organisations:	Healthy Waterways Partnership

4.1 Place

South-east Queensland is home to the majority of the state’s population. The region covers an area of approximately 23,000 square kilometres stretching from Noosa in the north to the Gold Coast in the south and west to the Great Dividing Range.

The economy and population of the region are dependent on the goods and services provided by its natural assets.

4.2 Challenge

Agencies responsible for ecosystem health and water quality management often have limited resources to undertake water quality monitoring to the level required for good planning and decision making consistent with the National Water Quality Management Strategy (NWQMS). Additional resources that may be available through volunteer or community groups are often not utilised, as the results provided by community-based monitoring have in the past been viewed with scepticism.

As a result, there is often insufficient data or information available to decision makers, and community groups can become disengaged in ecosystem health and water quality issues. These situations impede effective implementation of the NWQMS and limit potential improvements to local water quality.

4.3 Response

In order to capitalise on the community’s willingness to engage in water quality monitoring, without compromising the Healthy Waterways Partnership’s Ecosystem Health Monitoring Program (EHMP) and SEQ Catchments Ltd teamed up to develop a programme to build water quality monitoring capacity. The programme was a three-month trial that aimed to improve the capacity of local stakeholders (including local government and community groups) to undertake monitoring, interpret results and participate in decision-making processes. Another aim of the programme was to generally increase awareness of water quality issues in the region.

The trial was implemented using a consortium approach, with the formation of three subregional consortia comprising local government and community groups and overseen by a project working group.

Standardisation of water quality monitoring was achieved through the development of a training package, including standard quality assurance and quality control (QA/QC) protocols. The training

package consisted of an introductory model that covered the theory of water quality monitoring and a practical training manual that covered specific EHMP methods and QA/QC protocols. The training and assessment was structured to ensure that project participants received formal recognition and accreditation.

A critical element in the project was the development of monitoring plans. These plans were crucial because they:

- encouraged strategic planning of waterway monitoring projects
- provided confidence in the data collected
- led to enhanced communication between project participants and stakeholders
- enabled easier integration of multiple monitoring projects into a central alliance
- facilitated the development of successful partnerships between community monitoring groups and regional national resource management (NRM) bodies and state government agencies involved in waterway monitoring.

Part of the quality control of the trial involved the participation of community members in shadow testing with staff from the former Department of Environment and Resource Management. Shadow testing, where an expert tests the same field sample, was a good mechanism to demonstrate and verify the quality of community-collected data.

4.4 Results

The trial led to a significant increase in stakeholder participation in local monitoring using EHMP methods. Approximately 11 local councils and 25 community groups across south-east Queensland became involved in waterway monitoring through the trial. Many of these groups had not previously been involved in waterway monitoring. Over 120 participants successfully completed the accredited training, with everyone gaining a better understanding of water quality monitoring and catchment-based water quality issues. Participants also gained a better understanding of the complexities of the EHMP through the practical training sessions and shadow testing activities.

Shadow testing highlighted that, with correct calibration and quality assurance checks combined with fully trained personnel, the precision of water quality data is comparable to that of state agencies.

4.5 Benefits

New collaborative partnerships were established between community-based monitoring groups (including community volunteer groups and local councils), SEQ Catchments and the EHMP. Effective partnerships are critical to ensuring improved integration and alignment of waterway monitoring across the regions. These partnerships also resulted in improved communication and information sharing between the community and councils.

Through the development of the monitoring plans came a better understanding of various specific catchment-related processes. As a result, communities and councils have adopted and continued to use the monitoring regimes initiated during the trial, providing a much finer spatial scale of monitoring on a monthly basis.

4.6 Lessons learned

The project was ambitious in nature and the significant investment (both financial and in-kind) and goodwill provided by a wide range of stakeholders were crucial to its success. Lessons can be learned from the development of the training modules, which can be utilised in the future for training associated with water quality monitoring programmes.

The trial assisted in identifying a model of how community-based waterway monitoring can be supported in south-east Queensland to ensure ongoing involvement and enthusiasm. It also resulted in community education and capacity building through the collection of quality assured water quality data for use in education and awareness programmes as well as for improved planning and decision making.

The project and approach have wide transferability throughout Australia but will require adaptation in areas where financial and in-kind investment may be limiting factors. The project also clearly demonstrated that a collaborative approach to regional waterway monitoring, while challenging, has many benefits for more efficient and effective implementation of the NWQMS. Not the least among these benefits are the improved communication and levels of trust between stakeholders, better alignment of water quality management activities and the sharing of resources, including monitoring equipment.

5 Implementing the NWQMS in the South Australian Murray–Darling Basin

Table 4 South Australian Murray–Darling Basin—summary

NWQMS focus:	Environmental values and stakeholder engagement
Lead organisations:	SA Murray Darling Basin NRM Board and Environment Protection Authority (SA)
Contact:	08 8204 2000
Partner organisations:	SA Water, Department for Water (SA) and Department for Environment and Natural Resources (SA)

5.1 Place

The South Australian Murray–Darling Basin (SAMDB) catchment encompasses all of the catchments contributing to the Murray River basin downstream of the border of South Australia and Victoria / New South Wales. The 55,000 square kilometre catchment area has a wide range of climatic regions, from the dry arid northern and Mallee regions to the much higher rainfall area of the Eastern Mount Lofty Ranges.

The SAMDB’s aquatic ecosystems are diverse, unique and among the state’s most valuable assets. They support biologically diverse ecosystems and provide a range of services that sustain the livelihoods and lifestyles of many South Australians.

5.2 Challenge

Throughout the Murray–Darling Basin the use of aquatic ecosystems for economic and recreational activities has become more intensive and now places their interdependent social and economic values at risk. The intensive use is affecting the health of these environments to an extent that it now threatens the very features that make them so attractive and valuable. South Australia is at the end of the basin and faces large management challenges, particularly in the context of declining river flows.

5.3 Response

To address this challenge, the SAMDB Natural Resource Management (SAMDB NRM) Board and the Environment Protection Authority (EPA) are implementing the NWQMS framework, adapted to local conditions. The South Australian State Natural Resources Management Plan (2006) states that ‘all NRM programmes and projects that address water quality should involve processes that are consistent with the framework established by the NWQMS’. To set the water quality objectives to protect agreed environmental values (EVs) for surface water and groundwater, a ‘stream condition’ framework was needed to inform the process. For surface waters this framework needed to take into account how various stressors, including water quality, flow, habitat, and riparian vegetation condition, may interact with and influence aquatic ecosystem health. As South Australia is at the end of the Murray River system, the impact of whole-of-basin influences on flow and water quality was also important to consider.

5.4 Results

After standardising terminologies, key elements of the NWQMS process were incorporated into the SAMDB NRM Board plan and Environment Protection (Water Quality) Policy. This first step was vital in supporting the future planning and management of aquatic ecosystems in the SAMDB by:

- providing a blueprint for future management
- setting policy directions to protect ecosystem values while maintaining their economic and recreation values (for example, tourism, industry, fishing and agriculture)
- enabling better regulation of pollutant discharges to water bodies by incorporating regionally specific criteria into legislation
- providing information for government, industry and community planning activities
- informing where best to undertake management actions and make investment to improve water quality
- supporting targeted and cost-effective water quality monitoring programmes.

The SAMDB NRM Board recognised that implementing the NWQMS would involve an ongoing process of iteration. Their starting point was to integrate key elements of the NWQMS and related actions into their draft NRM plan. The Resource Condition Target for water quality in the SAMDB NRM plan and vision for 2030 was proposed as ‘Water quality that meets regionally endorsed environmental values’.

As the first step in implementing the NWQMS, proposed EVs were identified for aquatic ecosystems. The EVs are listed in Table 5. These reflect what the community valued or aspired to have for a particular water body, recognising that current condition may need to be improved to support these values.

Two key processes in developing the proposed EVs were the consideration of the current uses and values in the region and a survey of community values in the SAMDB. A wide range of current EVs were evident in the current water uses in the region. Some examples of the supporting information on the current water uses and EVs in the region are listed in Table 6 along with issues and threats to maintaining these values. To determine EVs for the region, the SAMDB NRM Board engaged the CSIRO to provide a set of tools to help determine the prioritisation of investment options for the maintenance and protection of natural assets.

The development of water quality objectives to achieve the regionally endorsed EVs is a key requirement of the NWQMS. The SAMDB NRM Board recognised that the condition of the aquatic ecosystems needed to be assessed to determine whether their current condition could support how the community would like to use these areas. A ‘stream condition index’ was developed by the EPA to integrate the various stressors that determine aquatic ecosystem health (for example, water quality, flow regimes and habitat condition) in surface water bodies.

Where multiple EVs are present for an aquatic ecosystem, targets would be set to protect the most sensitive value. The potential social and economic costs of meeting the targets would also be important to consider, and the SAMDB NRM Board further recognised that trade-offs may need to be made should this prove too difficult or costly to be acceptable to the community.

5.5 Benefits

The final outcome of the NWQMS development process in the SAMDB will be a water quality management plan (WQM Plan) for the region which will identify the causes of water quality degradation and set target values and management actions to improve water quality to a level that protects the designated environmental values. The WQM Plan will form part of the requirements of Water Resource Plans in the new Murray–Darling Basin Plan being developed under the *Water Act 2007* (Cth).

The development and implementation of the Basin Plan is particularly important for South Australia, as water quality is greatly influenced by upstream factors. For example, the extreme low flows during the 2007–2009 drought resulted in water quality changes that degraded key EVs in the lower river and lakes (for example, high salinity and acidification in localised areas). Implementing the NWQMS has provided the SAMDB NRM Board and EPA with an excellent basis to ensure appropriate targets are set in the Basin Plan and management actions are undertaken to protect key EVs into the future.

5.6 Lessons learned

Developing an agreed set of EVs and associated water quality objectives for waterways and groundwater throughout a catchment is a most significant NWQMS achievement. Involving key agencies and appropriately engaging the community in the process as early as possible is fundamental to achieving widespread endorsement and support.

These are among the most critical enabling steps in the process of progressively attaining desired water quality throughout catchments. The approach used in the SAMDB has wide transferability for adaptive implementation in other local and regional catchments throughout Australia. The development of flow and water quality objectives across the entire Murray–Darling Basin is critical to ensure EVs in the SAMDB are protected in the future.

Table 5 Environmental values for surface and ground water bodies in the SAMDB (what values the community gives water bodies)

Water bodies	Environmental values										
	Aquatic ecosystems—high conservation/ecological value	Aquatic ecosystems—slightly to moderately disturbed	Aquatic ecosystems—highly disturbed	Cultural and spiritual	Raw drinking water	Stock watering	Irrigating/irrigation	General farm use	Industrial use	Aquaculture	Human consumption
Murray River system	–	YES	–	YES	YES	YES	YES	YES	YES	YES	YES
Lower Lakes system	–	YES	–	YES	YES	YES	YES	YES	–	YES	YES
Coorong	YES	–	–	YES	–	–	–	–	–	–	YES
Encounter Bay	–	YES	–	YES	–	–	–	–	–	YES	YES
Major tributaries and their catchments	–	–	–	–	–	–	–	–	–	–	–
Finniss River	YES	–	–	YES	–	YES	YES	YES	–	–	–
Tookayerta Creek	YES	–	–	YES	–	YES	YES	YES	–	YES	–
Currency Creek	YES	–	–	YES	–	YES	YES	YES	–	–	–
Deep Creek	YES	–	–	YES	–	YES	YES	YES	–	–	–
Angas River	–	YES–	–	YES	–	YES	YES	YES	–	–	–
Bremer River	–	YES	–	YES	–	YES	YES	YES	–	–	–
Burra Creek	–	YES	–	YES	–	YES	YES	YES	–	–	–
Reedy Creek	–	YES	–	YES	–	YES	YES	YES	–	–	–
Marne River	–	YES	–	YES	–	YES	YES	YES	–	–	–
Saunders Creek	–	YES	–	YES	–	YES	YES	YES	–	–	–

Improving water quality: Stories of progress and success from across Australia

Water bodies	Environmental values										
	Aquatic ecosystems—high conservation/ecological value	Aquatic ecosystems—slightly to moderately disturbed	Aquatic ecosystems—highly disturbed	Cultural and spiritual	Raw drinking water	Stock watering	Irrigating/irrigation	General farm use	Industrial use	Aquaculture	Human consumption
Rocky Gully Creek	–	–	YES	YES	–	YES	YES	YES	–	–	–
Salt Creek	–	–	YES	YES	–	YES	YES	YES	–	–	–
Preamimma Creek	–	–	YES	YES	–	YES	YES	YES	–	–	–
Groundwaters	–	–	–	–	–	–	–	–	–	–	–
Noora	–	YES	–	YES	–	YES	YES	YES	–	–	–
Mallee	–	YES	–	YES	–	YES	YES	YES	–	YES	–
Marne–Saunders	–	YES	–	YES	–	YES	YES	YES	–	–	–
Eastern Mt Lofty Ranges	–	YES	–	YES	–	YES	YES	YES	–	–	–
Peake, Roby and Sherlock	–	YES	–	YES	–	YES	YES	YES	–	–	–
Tintinara–Coonalpyn	–	YES	–	YES	–	YES	YES	YES	–	–	–

Table 6 Examples of information on environmental values, management goals, and key pressures in the SAMDB

Current uses	Management goals	Key pressures
Supporting the intrinsic values of aquatic ecosystems in surface waters and groundwaters, including the Murray River, wetlands, streams/tributaries of the Murray River, Lower Lakes and Coorong, coastal waters and other saline environments	<p>Maintain or achieve good native freshwater fish and macro-invertebrate diversity in high conservation / ecological value areas</p> <p>Increase native freshwater fish and macro-invertebrate diversity in slightly to moderately disturbed areas</p> <p>Return riparian habitat to natural condition in slightly to moderately disturbed areas</p>	<p>Lack of flow in the Murray River (4,714 GL or 38% of natural median in 2009), drought conditions and unsustainable use of resources resulting in a significant decline in aquatic ecosystem health, connectivity of ecosystem and water levels</p> <p>Pollutant inputs from inappropriate development, wastewater disposal and poor land management</p> <p>Increasing salinities due to drought, land-clearing and irrigation (i.e. increased groundwater recharge and watertables) activities. Impacts on groundwater ecosystems (stygo fauna) are being increasingly studied and recognised</p> <p>Waterlogging of wetlands and swamps through supplementary water inputs to groundwater and maintenance of pool levels in the river</p> <p>Destruction or alteration of riparian zones</p>
Irrigation, including pasture, flood irrigation, dairy, vegetables, fruit, nuts and grapes. Approximately 58,000 ha under irrigation. Value of output \$640 million per annum (2000–01). Annual water allocation 548 GL (2005–06)	<p>Maintenance of water quality for irrigation of crops</p> <p>Maintenance of water quality for watering of gardens and lawns</p>	<p>Irrigation drainage and recycling resulting in salinity impacts on water</p> <p>Nutrient and microbiological inputs to the river from flood irrigation drainage</p> <p>Managing salt accumulation and its effects on soil</p> <p>Limited industry growth due to decreasing water allocations and salinity impact zones</p>
Primary recreation with direct contact with water, such as swimming or water skiing. Approximately 1,500,000 visitors in 2005 (contribution to GSP approximately \$221 million), 23% of whom are involved in primary recreation activities	Maintenance of surface water quality at a level suitable for swimming, water skiing and wakeboarding	<p>High river turbidity limits visibility of hazards, resulting in increased risks of injuries and deaths</p> <p>High pathogen levels may result in health risks to recreational users</p> <p>Toxic algal blooms, smell and odour problems may impact on health and amenity values</p>
Visual appreciation of waterways for picnicking, camping, bushwalking, sightseeing, etc. 70% of visitors are involved in visual appreciation activities	Maintenance of an attractive visual appearance of the surface water bodies	<p>High turbidity and large algal blooms that interfere with visual appreciation</p> <p>Fish kills</p> <p>Destruction or alteration of riparian zones</p> <p>Lack of environmental flows</p> <p>Inappropriate development that impairs visual amenity</p>

Improving water quality: Stories of progress and success from across Australia

Current uses	Management goals	Key pressures
<p>Cultural and spiritual values of water. Over 40,000 years of history with Indigenous and non-Indigenous communities traditionally dependant on the abundance of resources provided by the Murray River and its reaches</p>	<p>Maintenance of suitable water quality for Indigenous and non-Indigenous cultural and spiritual values Protection of Indigenous sacred sites Protection of important plant and animal communities Maintenance of traditional and spiritual uses of waterways Protection of early settler heritage sites</p>	<p>Diminishing natural food sources and habitats due to lack of flows and changing dynamics of the Murray River Exposure of culturally significant burial and other sacred sites due to falling water levels Sites of cultural significance under threat due to river in state of ecological decline Absence of specific water allocations for cultural use Removal of riparian vegetation (e.g. by clearing or grazing) used by Indigenous communities</p>

6 Integrating groundwater, water quality and water quantity at Tindall

Table 7 Water quality and quantity at Tindall—summary

NWQMS focus:	Stakeholder engagement, setting water quality objectives, and adaptive management
Lead organisation:	Katherine Water Advisory Committee—a subcommittee of the Daly River Management Advisory Committee (DRMAC)
Contact:	08 8999 4892
Partner organisation:	Water Resource Branch, Department of Natural Resources Environment, the Arts and Sport (NT)

6.1 Place

The Tindall Limestone Aquifer in the Katherine region represents one of the Northern Territory’s highest-yielding good-quality groundwater resources. The geological make-up of the Tindall formation is a karstic limestone aquifer system featuring spring discharge, sinkholes, limestone outcrops and intricate cave systems.

6.2 Challenge

The challenge in the top end of Australia is to manage aquifers so that water quantity and quality meet environmental, economic, social and cultural needs, particularly as water supply is often considered plentiful and reliable. However, the reality is that 90 per cent of annual rainfall falls during the wet season, while the remainder of the year is very dry.

Permanent watercourses in the Northern Territory are exclusively fed by groundwater in the dry season, with recharge to these groundwater systems being highly variable and reliant on rainfall.

The Tindall Limestone Aquifer at Katherine is a good example of these challenges. Recharge to the aquifer only occurs in areas where it is in direct contact with the ground surface, while discharges from the aquifer provide dry season flows in the Katherine and Daly rivers. There are significant ecological and cultural values associated with these rivers, while water from the Tindall aquifer also provides many social and economic benefits to the Katherine region.

6.3 Response

With water extraction and use in the Daly River catchment being concentrated around Katherine, managing these issues was the first priority. The Northern Territory Government established the Daly River Management Advisory Committee (DRMAC) in 2007 to address both water quantity and quality issues. DRMAC established a subcommittee (the Katherine Water Advisory Committee) to consider the scientific information and user requirements and develop a draft water allocation plan (WAP) for the Tindall Limestone Aquifer. This subcommittee included representatives from various stakeholder groups: Indigenous landowners, agriculture, horticulture, pastoralists, industry, conservationists, public utilities, tourism, local government, community and recreational users.

The WAP encompasses the section of the Tindall Limestone Aquifer located within the Katherine River surface water catchment boundary. It aims to ensure long-term sustainable water use in the

Katherine region to keep the Katherine River ecosystem healthy and provide water security to the Katherine community both now and into the future. In developing the WAP, seasonal variations, future climate change and requirements for agricultural and urban development were all considered.

However, assumptions were needed due to limitations in knowledge. These limitations were most apparent in the area of climate change and how it will affect water availability and the requirements for appropriate environmental and cultural flows. The public consultation process for the WAP included two rounds of public submissions/comments on draft WAPs and a public information session at the Katherine Town Hall.

In line with the National Water Quality Management Strategy (NWQMS), the WAP has introduced guidelines and procedures for protecting water quality. A range of environmental values (termed 'beneficial uses' in the Northern Territory) were identified and confirmed through the planning process (see Table 8). The WAP gives priority to water allocation for the environment and lifestyle. Water is made available for consumptive use only after these needs are satisfied. To ensure the integrated approach to water quality and quantity management, the WAP establishes performance indicators that will be monitored and assessed as prescribed under an implementation strategy. Indicators include annual extraction, groundwater levels, discharge from the Tindall Limestone Aquifer to the Katherine River, water quality and the ecological health of the Katherine and Daly rivers.

An implementation strategy will be developed for the WAP. Ongoing adaptive management will ensure monitoring, investigation, and compliance, and the information gained will be used to improve the WAP at scheduled five-year and 10-year reviews.

Table 8 Examples of beneficial uses for non-consumptive and consumptive uses

Non-consumptive use	Consumptive use	Example of beneficial use (environmental value)
Environment		Water to sustain limestone cave system and river ecology
Cultural		Water to sustain Indigenous subsistence and recreation such as camping and fishing
	Public water supply	Katherine town drinking water supply
	Agriculture	Water for irrigation of crops
	Aquaculture	Water to support commercial production of fish and crustaceans
	Industry	Water for irrigation of lawns and gardens attached to commercial premises
	Rural stock and domestic	Water for houses and livestock in rural areas

Note: Table 8 is directly derived from information presented in the WAP for the Tindall Limestone Aquifer, Katherine, 2009–2019.

The WAP for the Tindall Limestone Aquifer is a first for the wet/dry tropics in Australia and has broken new ground for Northern Australia integrated water planning. The WAP has been made in accordance with the NWQMS and the National Water Initiative, which requires that WAPs sustain

connectivity between surface water and groundwater and deliver an equitable distribution of water resources between competing uses, including environmental and cultural water requirements.

6.4 Benefits

The release of the WAP resulted in the following immediate and/or ongoing benefits:

- the introduction of standards and procedures to protect water quality
- the allocation of 73 licences with defined level of security
- sustainable management of flows from the Tindall aquifer to the Katherine River
- inclusion of Indigenous uses and values
- protection for groundwater-dependent ecosystems, such as the Katherine hot springs.

6.5 Lessons learned

The Tindall aquifer WAP demonstrates that water allocation planning and decision making can successfully embrace and integrate key facets of the NWQMS—specifically the determination of desired environmental values by both the community and government and associated water quality objectives (WQOs). The adaptive management approach as espoused by the NWQMS means that the amount of water provided for environmental, Indigenous cultural and other river-based public benefit outcomes could be modified in future based upon the results of the monitoring programme or new research findings.

An important outcome of the WAP is that flows are maintained throughout the dry season at sites of Indigenous cultural importance. While the correlation between the environmental and cultural requirements was high, it was recognised that environmental water requirements may not always align with Indigenous cultural, aesthetic and social requirements. However, the water requirements to sustain these specific uses are not well understood. Therefore, it was necessary to make the assumption in the WAP that the majority of cultural requirements would be met by providing the flows considered necessary to meet the identifiable environmental needs.

In considering how this approach may potentially be used for other regions facing similar challenges, a key lesson is that further information is necessary to quantify water requirements to specifically meet Indigenous cultural and other social needs.

Current research will assist in providing this information and will enable more specific provisions to be made to accommodate cultural needs. Research findings and additional lessons learned will be incorporated in future reviews of the Tindall WAP through the continuing adaptive management approach.

7 Improving the health of the Derwent Estuary

Table 9 Derwent Estuary—summary

NWQMS focus:	Science partnerships and stakeholder engagement
Lead organisation:	Department of Primary Industries, Parks, Water and Environment (Tas.), Derwent Estuary Program
Contact:	03 6233 6547
Partner organisations:	Tasmanian Government; Australian Government Department of Sustainability, Environment, Water, Population and Communities; Brighton, Clarence, Derwent Valley, Glenorchy, Hobart and Kingborough Councils; Southern Water; Norske Skog Boyer; Nyrstar Hobart; TasPorts; Hydro Tasmania; University of Tasmania; CSIRO Marine Research; and NRM South

7.1 Place

The Derwent Estuary lies at the heart of the Hobart metropolitan area in Tasmania and is a waterway of great natural beauty and diversity. It is an important and productive ecosystem, providing a wide range of habitats for a great variety of species. The estuary is widely used for recreation, boating, recreational fishing, marine transportation and industry.

7.2 Challenge

Like most Australian estuaries with urban and industrial development in their catchments, there are considerable challenges to improving environmental health in the Derwent Estuary, including:

- heavy metal contamination of sediments and corresponding effects on biota
- nutrient enrichment, organic-rich sediments and locally depressed oxygen levels
- altered environmental flows and physical barriers to fish migration
- introduced marine pests and weeds
- loss and degradation of estuarine habitat and species
- occasional faecal contamination of recreational waters.

Of these issues, the principal concern is the elevated levels of heavy metals in water, sediments and biota. Zinc, lead, mercury, copper and cadmium occur in sediments at levels well above those in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000). Estuary shellfish, particularly oysters and mussels, also contain heavy metals (specifically zinc and lead) in excess of those in Food and Safety Australia and New Zealand guidelines. Furthermore, mercury levels in flathead and bream are close to or above the recommended limit. Previous management has significantly reduced heavy metal loads with gradual improvements in estuarine condition. However, further action was needed to reduce loads and to manage risks associated with contaminated sediments and seafood.

7.3 Response

The Derwent Estuary Program (DEP) was established in 1999 to restore and promote the estuary (see Box 1 for details). In 2004, protected environmental values (PEVs) were set for the Derwent Estuary to provide water quality sufficient for the protection of aquatic ecosystems and fish suitable for human consumption. At that stage, the value of shellfish suitable for human consumption was set as a longer-term objective rather than a PEV.

In 2007 the Derwent Estuary Water Quality Improvement Plan (WQIP) was developed and prepared in accordance with the NWQMS with funding received by the Australian Government. This plan reviewed heavy metal sources and loads, set environmental targets and recommended actions to reduce heavy metal sources and manage loads.

The large area of contaminated sediments in the Derwent Estuary raised a number of important questions for management, including the following:

- Are sediments a major contributor of metals to the water column?
- Are there conditions under which they could become a major source?
- What are the ecological implications of these contaminated sediments in terms of both toxicity and bioaccumulation?
- Could remediation of sediments or reductions of ecological and human health risks be feasibly achieved?

Considerable scientific effort was needed to begin to answer these and other questions. This was undertaken in collaboration with the University of Tasmania, CSIRO and private sector.

The major studies included:

- development of detailed estuarine models to support the WQIP by CSIRO
- extensive sediment and biological investigations, including an associated survey of benthic invertebrate communities by University of Tasmania researchers
- assessments of heavy metal discharges. This included major industries, sewage treatment plants, urban stormwater and the Derwent River catchment
- reviewing and undertaking a preliminary assessment of environmental flow issues and objectives.

7.4 Results

This work resulted in the selection of zinc as a key indicator of heavy metal levels and loads. The single largest source was found to be due to point source pollution from the historic Hobart zinc smelter, with the majority of the current load coming from past groundwater contamination at the site. The second largest source identified was urban stormwater run-off. A water column target of 15 µg/L total zinc was selected, corresponding to the NWQMS trigger level to protect 95 per cent of species in a slightly to moderately disturbed system. It is planned to refine this target over time as further information becomes available.

Metals occurring in estuary sediments were found to be strongly bound to these sediments and were not readily leached to the overlying water column under normal conditions—that is, no or little physical disturbance; thus metal release from sediments appears to be a relatively minor source of

heavy metals. Cores collected at several sites around the estuary indicated that metal levels were highest at a depth of 10 to 20 centimetres, suggesting that the most heavily contaminated sediments were being gradually diluted over time by deposition of cleaner sediments. Generally, heavy metal levels in sediments collected from intertidal areas near reserves and recreational areas did not exceed guideline levels for human exposure.

Initial toxicity screening suggested that sediments and waters were not highly toxic. However, tests using more sensitive species indicated significant sediment toxicity in some areas. The survey of benthic invertebrate communities found a diverse and abundant fauna living in sediments throughout the Derwent. Contrary to expectations, heavy metal contamination was not determined to be an overriding factor controlling benthic community structure in the estuary as a whole. Areas with high levels of heavy metals sustained abundant but modified faunal populations, suggesting that either the bioavailability of metals was low or possibly that the surviving organisms were less sensitive to the contaminants.

The issue of bioaccumulation (the potential for heavy metal accumulation up the food chain), rather than toxicity or direct metal fluxes, was of more significant concern. For instance, caged oyster experiments demonstrated that there was a rapid uptake of zinc by these organisms, both in surface waters and at depth. As a result, a more detailed assessment through further scientific studies was recommended.

7.5 Benefits

Water quality management in the Derwent has benefited from the improved understanding generated by the preparation of the WQIP. This process resulted in the identification of several management actions for implementation over the next five to 10 years, including:

- further capture and remediation of contaminated groundwater and stormwater at the Hobart zinc smelter site
- development of dredging guidelines and protocols to avoid disturbing contaminated sediments
- management of nutrient loads so as to prevent low oxygen levels (which could cause sediments to release heavy metals)
- more detailed assessments of heavy metals in fish and biota
- raising community awareness about seafood safety and providing them with relevant information.

Implementing these actions will lead to further benefits for the estuary and the local communities by further reducing heavy metal loads, improving the management of contaminated sediments and reducing the risks due to heavy metals in seafood.

7.6 Lessons learned

Uncertainty may exist at a number of levels when it comes to evaluating the biological effects of heavy metal contamination and also in selecting the most appropriate management responses. This uncertainty may be reduced by further research to improve the understanding of the system under consideration and its response to interventions. Improving knowledge is valuable in informing and improving water quality planning and decision making for environmental and human health.

However, scientific knowledge alone cannot attain desired environmental values, and associated water quality objectives developed through stakeholder engagement are essential. Long-term partnerships greatly facilitate successful implementation of the NWQMS. In this case, while on-site load reductions to achieve water quality targets may be achievable within a few years, there will be a lag time before improvements are observed. This serves to reinforce what is perhaps the key lesson to be learned from the 10 years of experience in the Derwent—improving estuarine health and water quality is a long-term pursuit that is best addressed through enduring partnerships and stakeholder engagement processes and informed by sound and current scientific understanding. Good science and good stakeholder engagement are two foundational elements of the NWQMS that are pivotal to improving water quality.

Box 1 The Derwent Estuary Program—10 years of success in working together

The Derwent Estuary Program (DEP) is a regional partnership between local governments, the Tasmanian Government, commercial and industrial enterprises, scientists and community-based groups that was established in 1999 to restore and promote the estuary. It has been nationally recognised for excellence in coordinating initiatives to reduce water pollution, conserve habitats and species, monitor river health and promote greater use and enjoyment of the Derwent Estuary foreshore. In 2010, the DEP was awarded the prestigious National Riverprize.

Ten years after its formation, the DEP released its latest environmental management plan. Compared to its first plan, this covers a wider range of issues, including foreshore use and amenities, communications and a more detailed science and monitoring plan. The new plan is based on a 10- to 20-year horizon. It confirms the DEP's experience that a strategic and coordinated management approach across all levels of government, industry and the community remains the best prospect for a cleaner and healthier estuary in the future.

The DEP currently manages monitoring activities, projects and communications valued at over \$1 million per year. Partnerships and good science are at the core of the DEP's operations.

Despite the pressures it faces on a daily basis, the Derwent is showing promising signs of recovery. Since 1999, heavy metal and organic loads have declined by over 50 per cent in response to management actions undertaken by industry. Improvements have also been made to the water quality of sewage discharges through advanced treatment and effluent re-use, and a number of stormwater treatment projects have been completed by local councils. Improved management of boat wastes has also been achieved through collection and treatment of slipway wastes.

As the condition of the estuary has improved, the interest in conserving and enjoying the Derwent's natural features has increased. The DEP has led initiatives to acquire wetlands—increasing the area of protected wetlands by 40 per cent—and to preserve iconic species such as the little penguin and spotted handfish. More recently, the DEP has developed strategies to extend and link foreshore tracks and to use interpretative signage to increase awareness and enjoyment of the Derwent.

The DEP is underpinned by a comprehensive monitoring programme that documents environmental conditions and trends and also supports scientific research on key issues such as heavy metals and nutrient processing. The DEP informs the community about estuary conditions,

trends and management actions via quarterly eBulletins, annual 'Report Cards' and five-yearly 'State of the Derwent' reports.

8 Great Barrier Reef—Reef Water Quality Protection Plan

Table 10 Reef Water Quality Protection Plan—summary

NWQMS focus:	Adaptive management
Lead organisations:	Department of Sustainability, Environment, Water, Population and Communities and Department of the Premier and Cabinet (Qld)
Contact:	02 6274 1111
Partner organisations:	Local natural resource management (NRM) groups (NQ Dry Tropics, Burnett Mary Regional Group, Fitzroy Basin Association, Reef Catchments, Terrain NRM and Cape York Sustainable Futures), peak agricultural industry bodies and other Australian and Queensland government departments

8.1 Place

The Great Barrier Reef (the Reef) is located off the coast of central and northern Queensland. It contains a vast array of coral reefs, atolls and lagoons, spanning more than 2,300 kilometres. The Reef is recognised both nationally and internationally for its outstanding natural, social and economic values. It was one of Australia’s first listed World Heritage Areas and is the world’s largest World Heritage Area.

8.2 Response

The Reef Water Quality Protection Plan (Reef Plan) is a joint Australian and Queensland government initiative that specifically focuses on non-point source pollution. The Reef Plan sets ambitious but achievable targets for water quality and land management improvement and identifies actions to improve the quality of water entering the reef. The goals, objectives and targets are outlined in Box 2.

Initially established in 2003, the Reef Plan was updated in 2009. It details specific actions and deliverables to be completed by 2013.

With significant investment from both the Australian and Queensland governments, a number of other key activities were also undertaken between 2003 and 2009, including establishment of a regional water quality partnership encompassing natural resource management (NRM) organisations within the Reef catchment area as well as the Australian and Queensland governments. This partnership was formed to enable coordinated, scientifically robust and collaborative target setting, monitoring and reporting. The partnership contributed to:

- the development of water quality improvement plans (WQIPs) in each of the NRM regions
- the development of water quality objectives based upon the National Water Quality Management Strategy (NWQMS)
- a review of the 2003 Reef Plan
- a summit engaging stakeholders in the development of an updated Reef Plan

- several detailed scientific investigations, reviews and research studies to support the development of WQIPs and the updated Reef Plan.

8.3 Results

The 2003 Reef Plan resulted in a number of successes, including:

- coordinated and integrated water quality target setting, monitoring and reporting
- improvements in land management through incentives (for example, extended leases) and regulation (for example, land-clearing controls)
- identification of sedimentation hotspots and nutrient management zones
- implementation of many collaborative education and extension projects, particularly in relation to sustainable agriculture
- establishment of community-based water quality monitoring networks and programmes
- development and implementation of industry-led programmes to improve land management practices
- creation and use of mapping, decision support and information tools to assist land managers to protect and enhance wetlands.

However, an audit of the 2003 Reef Plan also identified a number of challenges. The 2006–07 annual report identified that 41 of Reef Plan’s 65 actions had met their original milestone. Of the remaining 24 actions, 18 were progressing well, but six showed unsatisfactory progress. The audit recommended that partnerships with stakeholders needed to be more effective and that consultation and communication were key areas for improvement. In addition, the audit recommended that the Reef Plan needed to be revised and relaunched with a renewed commitment from the Australian and Queensland governments. A further recommendation was made to improve the monitoring of land condition.

The audit and review processes led to development of the 2009 Reef Plan. Building upon the 2003 Reef Plan, the 2009 Reef Plan is better targeted with clearly established responsibilities. It is focused on addressing water quality issues caused by diffuse pollution and broad-scale land use. Urban and point source water quality issues are considered within other plans.

Whereas the 2003 Reef Plan had a long list of actions (65 in total), the 2009 Reef Plan contains two water quality goals (one immediate and one long term). There are two objectives to meet these goals, two types of targets to measure success (water quality and management practice) and 11 actions with clearly identified responsibilities and activities grouped into three priority work areas.

The \$200 million Caring for our Country initiative Reef Rescue programme is the Australian Government’s key approach to implementation of the 2009 Reef Plan. Reef Rescue investments are targeted at priority locations and improved land management practices using the best available science and expert advice.

Some of the results achieved under this programme relating to the 2009 Reef Plan targets include the following:

- By 2012, the programme has provided financial assistance to more than 2,500 land managers over 3.2 million hectares to date and is well on track to meet Caring for our Country – Reef Rescue targets.
- More than 1,100 farmers have undertaken projects to improve fertiliser, pesticide and soil management on over 500,000 hectares of land, representing 75 per cent of the five-year farmer engagement target achieved after three years.

8.4 Benefits

Improvements in water quality are a long-term undertaking; hence, it is too early to ascertain the impacts of actions to date on water quality. However, the considerable work already completed has delivered the following benefits:

- a strategic and adaptive 2009 Reef Plan that is more tightly focused than the 2003 Reef Plan
- a Reef Plan that addresses implementation and institutional issues and arrangements
- clear and measurable targets
- improved accountability
- more comprehensive and coordinated monitoring and evaluation
- greater scientific knowledge and understanding of key issues
- better cooperation among key stakeholders
- pivotal commitment of Australian and Queensland government resources.

8.5 Lessons learned

Adaptive management is a key process underpinning the NWQMS. The NWQMS implementation guidelines outline the way forward in identifying and agreeing on desired environmental values for water bodies, applying science to develop water quality objectives and targets, then pursuing these with regular reviews until they are ultimately attained.

The audit and review process has resulted in a Reef Plan that is more strategic and adaptive than the 2003 Reef Plan. The review process has also enabled the 2009 Reef Plan to include strategies to address previously identified problems (such as a lack of effective communication and engagement with stakeholders and partners). The 2009 Reef Plan also seeks to improve implementation and institutional arrangements, which are critical for effective action across a large number of diverse catchments.

The investment in detailed scientific investigations was essential in developing the 2009 Reef Plan. These investigations have provided the scientific foundation for setting water quality and land management targets as well as the Reef Plan's goals and objectives.

The approach to implementing the NWQMS for the Reef can be transferred to other large and multi-jurisdictional regions; however, there is a pivotal need to secure continuing commitment from Australian, state and territory governments. In such large areas, resources well beyond those that regions alone can provide are required to ensure that implementation, monitoring and adaptive review continue and deliver the level of water quality required to sustain the environmental values desired.

Box 2 Reef Plan goals, objectives and targets

Goals

- Halt and reverse the decline in water quality entering the Reef by 2013.
- Ensure that, by 2020, the quality of water entering the Reef from adjacent catchments has no detrimental impact on the health and resilience of the Great Barrier Reef.

Objectives

- Reduce the load of pollutants from non-point sources in the water entering the Reef.
- Rehabilitate and conserve areas of the Reef catchment that have a role in removing water-borne pollutants.

Water quality targets

- By 2013 there will be:
 - a minimum 50 per cent reduction in nitrogen and phosphorus loads at the end of catchments
 - a minimum 50 per cent reduction in pesticides at the end of catchments
 - a minimum of 50 per cent late dry season groundcover on dry tropical grazing land.
- By 2020 there will be a minimum 20 per cent reduction in sediment load at the end of catchments.

Management practice targets

- By 2013:
 - 80 per cent of landholders in agricultural enterprises (sugarcane, horticulture, dairy, cotton and grains) will have adopted improved soil, nutrient and chemical management practices
 - 50 per cent of landholders in the grazing sector will have adopted improved pasture and riparian management practices
 - there will have been no net loss or degradation of natural wetlands.
- The condition and extent of riparian areas will have improved.

9 The Northern Agricultural Region Targeted Investment Program

Table 11 Northern Agricultural Region Targeted Investment Program—summary

NWQMS focus:	Integrated water quality management implementation
Lead organisation:	Northern Agricultural Catchments Council
Contact:	08 9938 0100
Partner organisations:	Australian Government and Government of Western Australia

9.1 Place

The Moore, Minyulo and Hill river systems are important waterways with high-value estuaries in the Northern Agricultural Region of Western Australia.

9.2 Challenge

Land degradation in the upper catchment is threatening water quality through salinisation and increasing sediment and nutrient loads. Earlier land clearing and land management practices have resulted in groundwater rising at a rate of 50 centimetres per annum over the past 50 years. Approximately 50,000 hectares of highly productive agricultural land, known locally as the Otorowiri Zone, is subject to increased waterlogging and spreading salinity as watertables continue to rise.

This saline groundwater has the potential to migrate into adjacent fresh water aquifers and also increase saline base flows entering the Moore, Minyulo and Hill rivers, further increasing salt loads. Without large-scale intervention, the impact of decreased water quality and degradation or loss of natural resources will be even more significant.

9.3 Response

The Northern Agricultural Catchments Council (NACC) has responded to this challenge and developed the Targeted Investment Program (TIP) in consultation with regional groups, agronomists, hydrologists and biologists and representatives at all levels of government.

The TIP provided landholders with the opportunity to access incentives to establish perennial pasture, actively manage remnant native vegetation, better manage saline/waterlogged land, establish farm forestry and undertake strategic revegetation. The rationale underpinning the TIP was that large-scale land use change from 'leaky' annual agricultural production systems to preferred higher water use perennial systems, would increase soil water uptake and result in a corresponding drop in the level of recharge with less water percolating to the groundwater tables.

9.4 Results

The TIP identified high-priority natural resources, including rivers, native vegetation and agricultural land, that were under threat from increasing salinity and declining water quality and assisted land managers to adopt practices to address these threats.

9.5 Benefits

The TIP overcame many of the challenges facing landholders, frontline staff and regional coordinating bodies in delivering integrated catchment management programmes to improve water quality and catchment condition. It had the following real and tangible benefits:

- *Communication*—TIP officers provided frontline contact and a ‘one-stop shop’ for landholders. This provided a variety of services ranging from technical expertise through to developing and finalising incentive management agreements and inspecting completed on-ground works.

Communication was also assisted via a quarterly newsletter, fact sheets, field days and workshops and presentations at relevant events.

All contact between officers and the landholder was recorded in a database, including what was discussed and how information was disseminated. Records on landholders’ needs and interests enabled improved understanding and the contact history data assisted new officers joining the programme.

- *Consistency*—the TIP used comprehensive procedures, protocols, templates, standard guidelines and site criteria to enable consistent delivery of the incentives across the entire programme. Templates were provided for site assessments, management agreements, site establishment and management plans, on-ground works certification forms, site inspection forms and agreement tracking.

Procedures and protocols made it possible for different team members to quickly take over and manage matters when required. Meeting the standards and requirements ensured fairness and consistency in delivery as well as value for the public and private funds being invested.

- *Monitoring and assessment*—the standardised site assessment form provided baseline data for the site and informed the development of a site management plan. This plan guided the farmer through any establishment activities and long-term management requirements for the site. A site map formed part of the management agreement and enabled the capture of GPS data to create accurate, standardised spatial data using a customised ArcGIS tool.
- *Certification*—data collected during the certification process provided baseline data on establishment rates for use in future monitoring. Assessment was based on the work standards and establishment activities discussed during the site assessment phase and included in the fact sheets and management agreements.

For the landholder to receive payment, the on-ground works had to meet or exceed the defined standards. During the certification process, photo points were set up to provide a photographic record of the site at the completion of the works. Landholders received a map showing the photo points and a copy of the photos to assist future monitoring of outcomes and facilitate adaptive management.

9.6 Lessons learned

Implementing the NWQMS requires approaches that integrate with other natural resource management and catchment initiatives and strategies. The TIP built upon experience with integrated implementation approaches in other catchments across Australia and especially within the Murray catchment in New South Wales. Its component elements and the overall approach have wide transferability to many other regions, and some key lessons include the following:

- Have clear, unambiguous procedures, protocols, guidelines and criteria in place. This enables consistent delivery across a range of sites, and the landholders know what they will get and what is required of them from the beginning.

- GIS and database systems should be robust, easy to use and reflect the needs of the organisation.
- Ensure direct employment of staff responsible for developing work plans and priorities to enable timely delivery of the programme.
- Good support is required for new staff to ensure correct standards and procedures are adhered to and applied.
- A quality assurance process is needed to ensure agreements sent out to farmers meet guidelines and criteria.
- Payment of incentives after the completion and inspection of the works provides the basis of a sound risk management strategy for the accountable delivery of public funds.
- Yearly reviews of incentive levels are required to meet changing costs.

10 EcoHealth—Northern Rivers Ecosystem Health Monitoring Program

Table 12 Northern Rivers Ecosystem Health Monitoring Program—summary

NWQMS focus:	Integrated water quality monitoring
Lead organisations:	Northern Rivers Catchment Management Authority and Office of Environment and Heritage (NSW)
Contact:	02 6561 4965
Partner organisations:	Local and state governments and universities

10.1 Place

The Northern Rivers region of New South Wales is home to over 450,000 people and supports a thriving agricultural industry, as well as commercial and recreational fisheries and tourism. The region includes areas of great cultural, social and environmental significance, including World Heritage Areas and marine parks. Maintaining and improving ecosystem health is essential to retaining its environmental values and to sustain the ongoing prosperity of the region and its communities.

In 2005, the Northern Rivers Coastal Partnership Forum identified that fragmented responsibilities and monitoring programmes were inhibiting good decision making, reporting and progress in improving water quality.

10.2 Response

The first step in developing a coordinated and standardised monitoring and reporting programme for waterway condition in the Northern Rivers involved establishing a working group. The working group was given the responsibility of investigating whether an Ecosystem Health Monitoring Program would provide a suitable model for the Northern Rivers region. This was followed by a scoping study, which examined the use and regional applicability of the South East Queensland (SEQ) Healthy Waterways Ecosystem Health Monitoring Program.

The SEQ approach was particularly attractive to the Northern Rivers region for a number of reasons, including:

- the development of ongoing effective partnerships between local government, state agencies, industry and research organisations
- the integrated monitoring of biological, physical and chemical indicators at a large number of freshwater, estuarine and marine sites and use of this information for planning and management
- a sound underpinning in science and a ‘catchment to coast’ philosophy that recognises interconnections
- development of regional ‘report cards’ on the health of aquatic ecosystems and the effectiveness of management actions

- the use of standardised monitoring methods and data quality assurance techniques.

The scoping study confirmed that the SEQ model of ecosystem monitoring could be adapted and applied to the Northern Rivers region. To determine how to implement this approach, strategic planning sessions were held to explore the potential options. Key partnerships were formed in order to develop an ecosystem health monitoring programme for the Northern Rivers that would deliver benefits to the environment and community, including water quality improvement.

A technical panel of experts from government and universities worked through the selection of appropriate indicators and sampling design and logistics, while an advisory panel, consisting of local government representatives, explored funding options for the programme. Out of this process, a pilot EcoHealth programme was developed for the Bellingen Shire, with support from Northern Rivers Catchment Management Authority, Bellingen Shire Council, the University of New England and the New South Wales Office of Environment and Heritage.

The 12-month programme commenced late in 2009 with monthly monitoring of 12 water quality parameters and annual assessment of riparian vegetation and biological indicators, including freshwater fish and macro-invertebrates. This was followed by analysis and reporting through a technical report and the production of a report card. Results from [Bellinger and Kalang Rivers EcoHealth](#) are publically available. For more information, see the [New South Wales Government Local Land Services North Coast website](#).

Port Macquarie Hasting Council and Coffs Harbour City Council began the second EcoHealth pilot programmes in January 2011 incorporating lessons learned from the Bellingen project. The Northern Rivers Catchment Management Authority anticipates that all New South Wales Northern Rivers councils will implement EcoHealth in the near future with the aim of repeating the process on a three-year cycle to monitor changes in the catchment condition and assist with state monitoring, evaluation and reporting and Regional State of the Environment reporting.

10.3 Results

The initial scoping study found that the existing monitoring effort was:

- being conducted in 18 local government areas (LGAs)
- concentrated in estuaries with little freshwater monitoring and only some beach monitoring
- driven by existing reporting processes, particularly sewerage treatment plant licence conditions, State of the Environment reports and Beachwatch
- variable across the region, with large differences between LGAs in terms of expenditure (\$2,000 to \$600,000), the number of sampling locations, sampling frequency and the variables being measured.

The scoping study made recommendations to improve the monitoring process so that the data and information would become more representative of the system. The recommendations included:

- dramatically increasing the number of long-term freshwater and coastal lake sites within the monitoring programme
- monitoring a consistent range of physical, chemical and biological indicators
- testing the findings of the scoping study with a pilot study before rolling out a broader programme across the region.

The cost of the revised monitoring programme was estimated to be about \$1,900,000, or 30 per cent higher than the current regional expenditure on monitoring.

10.4 Benefits

The development process of EcoHealth, the Northern Rivers monitoring and reporting programme, has provided stakeholders with a much better understanding of the nature and scope of monitoring that is occurring across the region and how it could be improved.

It has also helped build partnerships and networks, with local and state government agencies, industry and universities all being involved in the process to date.

It is anticipated that the EcoHealth programme will enhance the ability of resource managers to monitor, measure and report on ecosystem health by establishing a statistically valid and quality-assured sampling regime. The benefits of a standardised, region-wide system include:

- improved public information on waterway health and management actions in local catchments through report cards
- improved decision making on natural resource management action and investment
- mobilisation of on-ground action through report card grades
- improved management, access and sharing of data
- enhanced communication about waterway health between natural resource management agencies, local government, other stakeholders and the community
- consistency and efficiency in sampling, analysis and reporting across government natural resource management agencies, including the establishment of permanent sampling sites to monitor long-term impacts such as climate change.

10.5 Lessons learned

This project builds upon the pioneering work of the SEQ Ecosystem Health Monitoring Program, including the production of report cards. It is highly transferable to other regions wishing to coordinate and standardise monitoring and reporting of waterway condition. The initiative clearly demonstrates the significant progress that can be made to enhance the implementation of the NWQMS by learning from others. Excellent progress, as well as improved cost-effectiveness, in water quality monitoring and management is found where people, organisations and regions generously share successes and setbacks, knowledge, experience and wisdom.

11 Adaptive management of the Port Waterways of Adelaide

Table 13 Port Waterways of Adelaide—summary

NWQMS focus:	Adaptive management
Lead organisation:	Environment Protection Authority (SA)
Contact:	08 8204 2000
Partner organisations:	SA Water, Penrice Soda Holdings and the Australian Government Department of Sustainability, Environment, Water, Population and Communities

11.1 Place

The Port Waterways of Adelaide is an area of major ecological, commercial, cultural and recreational importance to Adelaide. People care about this ecosystem, and sightings of dolphins are an especially valued part of people’s experience of this area. Indeed, all South Australians share in the prosperity that the nearby trade and industry bring.

11.2 Challenge

Over the years, water quality in the Port River and Barker Inlet area has declined. An excess of nutrients from discharges into the waterways—mostly nitrogen and phosphorus—have degraded the ecosystem. Excess nutrients are the cause of algal blooms which have killed fish and clogged mangrove roots as well as causing unpleasant odours and the loss of seagrasses. While many people are working hard to achieve restoration, a plan was needed to coordinate these activities and achieve a common purpose and direction. Once again, the NWQMS framework was drawn upon to enable substantive progress towards achieving the improved water quality so clearly desired by both community and government.

11.3 Response

Consistent with the NWQMS and with the financial support of the Australian Government and other stakeholders, a water quality improvement plan (WQIP) was developed for the Port Waterways. Work began by asking residents, industries and interest groups what the waterways mean to them. People were also asked about how the waterways should be used and to identify what were the present obstacles to being able to use this waterway as desired. This process enabled environmental values (EVs) to be set for the waterways and development of water quality objectives (WQOs) to achieve or maintain these EVs.

A full audit of all discharges to the waterways was then completed and a computer model developed. This increased understanding of how discharges to the waterway would have to change to meet the water quality standards. The results of the audit, the modelling and the options were all presented in a draft plan.

The computer model was validated using real conditions in the waterways and, as expected, it provided a good indication of what was really happening. While a margin of safety was initially

applied to the discharge targets, through time it is expected that the data collected from waterway monitoring will enable water quality targets to be refined—possibly upwards a little.

11.4 Results

Table 14 shows how nutrient loads in the waterways have changed over the period 1995 to 2010 as a result of activities prior to the WQIP.

Table 14 Nitrogen and phosphorus loads and targets for principal sources (tonnes per year)

Source	1995		2004		2010		Target	
	N	P	N	P	N	P	N	P
Catchment and stormwater sources	75	19.2	41	3	36.5	2.7	36.5	2.7
Regional groundwater	10	0.25	10	0.25	10	0.25	10	0.25
West Lakes	30	3	41	6	41	6	41	6
SA Water	1776	320	477	232	477	232	104	44
Penrice Soda products	1300	3	820	0.7	575	0.2	250	0.2
Other licensed	7	2.4	7	2.4	5.8	2.3	5.8	2.3
Recreation	10	2	10	2	8	1.6	8	1.6
Sediment	<100	<10	<100	<10	<100	<10	<100	<10
Atmospheric fallout	32	2	32	2	32	2	32	2
Total	3340	361.9	1538	258.4	1285.3	257.05	587.3	69.1

N: nitrogen; P: phosphorus

Substantial reductions in nitrogen and phosphorus have been achieved from some sources, but there are still considerable challenges to be met. SA Water is responsible for most of the nutrient load reductions to the waterway to date and provides a good case in point. Its nitrogen discharge has reduced from almost 1,800 tonnes in 1995 to less than 500 tonnes in 2004. The cost of this to taxpayers has been over \$200 million. Most of the Bolivar plant discharge now travels north, out of the Port Waterways.

The attainment of the desired WQOs will require the implementation of the agreed adaptive management approach (see Box 3).

11.5 Benefits

Through the adaptive management approach of the WQIP, further improvements to water quality, including changes to the discharge targets, may be anticipated over time. For example, the main discharger, SA Water, is a leader in the supply of wastewater for crop production, and a large proportion of its discharge is diverted for this in summer.

SA Water is working with the Environment Protection Authority with the intention of developing sustainable storage of winter wastewater discharges in underground aquifers for use during summer.

The very good prospects of the WQIP resulting in further reductions in nutrients will benefit the ecosystems throughout the Port Waterways and the resulting EVs. Each step forward will

progressively reduce the considerable challenges that still face industry and the South Australian community. A pivotal benefit of the WQIP has been that this framework, based on the NWQMS, has brought all the key players and the community together and engendered real commitments from everyone to achieve a sustainable waterway.

11.6 Lessons learned

The structured approach to adaptive management through the WQIP for the Port Waterways of Adelaide is highly transferable throughout Australia. Successful adaptive management requires that ongoing resources be applied to the WQIP to ensure that all stages of the cycle are undertaken on a regular basis. Failure to do this will result in extra costs for dischargers, the community and the ecosystem. Conversely, diligent application of an adaptive management framework will allow for achievement of agreed EVs in an efficient manner that is transparent to all stakeholders.

The required reductions in discharges represent a considerable challenge to industry and to the South Australian community. These stakeholders recognise that improving water quality is a long-term process and that, consistent with the NWQMS, an adaptive management process is crucial to success. This work is being extended across all of Adelaide's coast with the development of an Adelaide coastal WQIP. The plan will be fully reviewed every five years to fit in with State of the Environment reporting in South Australia and be subject to minor review and possible changes every 12 months in its first cycle.

Box 3 Adaptive management in the Port Waterways of Adelaide

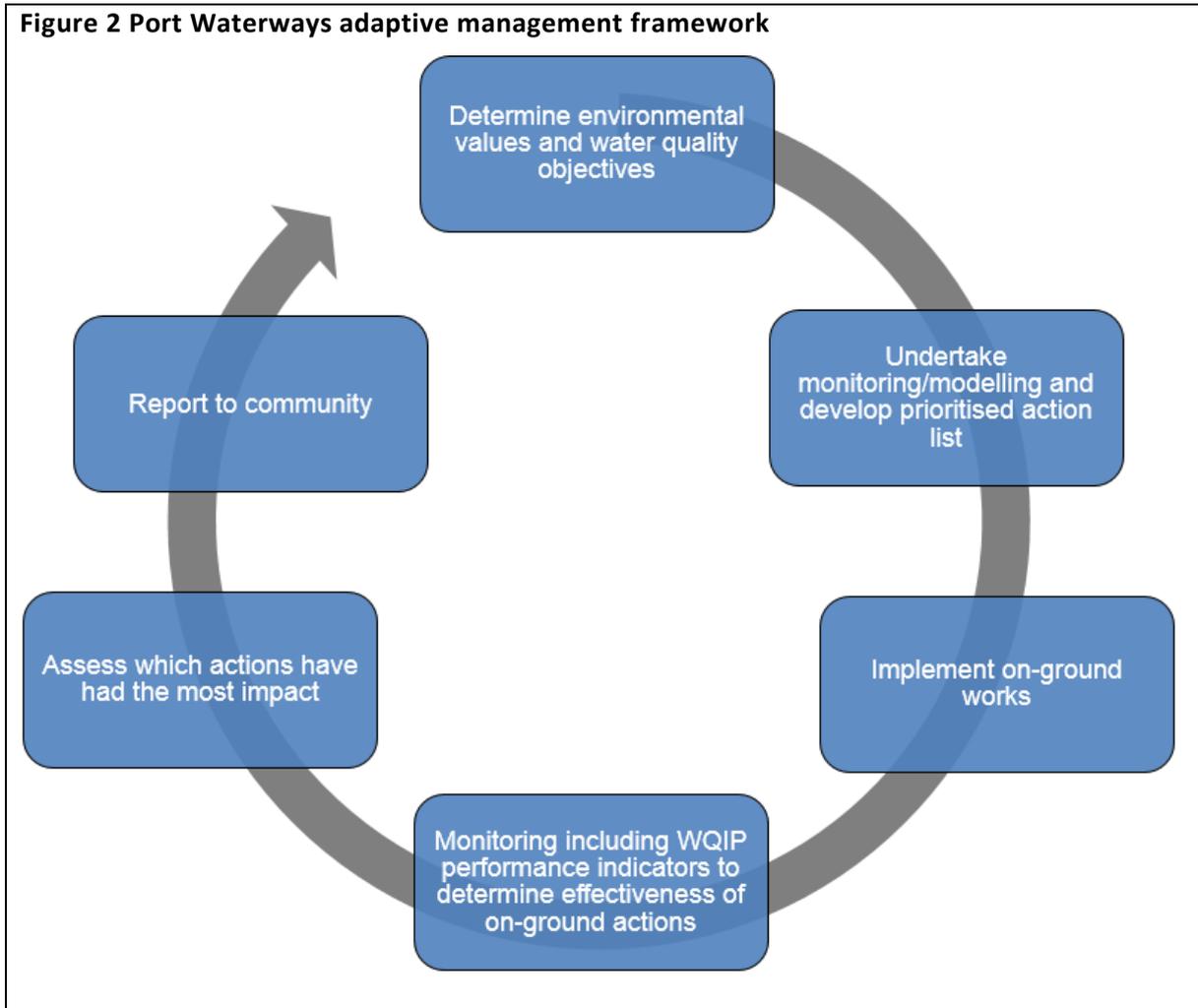
Adaptive management in the WQIP aims to:

- find better ways of improving the health of the Port Waterways
- identify key gaps in understanding of the system
- improve understanding of the ecosystem responses, thresholds and dynamics in order to adapt practices to fit changing social and economic values and ecological conditions
- integrate information about the whole of the waterways where appropriate, rather than focusing only on the immediate area around various discharges
- gain reliable feedback about the effectiveness of alternative policies/practices
- encourage innovation and learning
- pass on information and knowledge gained through experience
- foster an organisational culture that emphasises learning and responsiveness.

A schematic diagram of the adaptive management framework as it applies to nutrients in the Port Waterways is shown in Figure 2. For success, all six steps must be undertaken and the omission of one or more will hamper the ability to learn from management actions.

In addition, documenting the key elements of each step and communicating results are crucial to building a 'legacy of knowledge' of both current and future plans.

Figure 2 Port Waterways adaptive management framework



12 Developing an effective monitoring programme for New South Wales

Table 15 New South Wales monitoring programme—summary

NWQMS focus:	Integrated monitoring
Lead organisation:	Office of Environment and Heritage (NSW)
Contact:	02 9995 5000

12.1 Place

The natural environment in New South Wales has a diverse range of landscapes and ecosystems. These range from the fertile agricultural areas along the coast and on the western slopes of the Great Dividing Range to the semi-arid plains in the state’s west and the alpine and highland areas along the Great Dividing Range down to coastal lowlands.

12.2 Challenge

This great diversity of landscapes and ecosystems presents significant challenges in developing and implementing state monitoring systems to improve ecosystem health and water quality. In addition, factors such as costs and resource constraints, differing information and reporting needs among stakeholders, history and confusion about objectives often impede effective monitoring.

The National Water Quality Management Strategy (NWQMS) provides a framework and guidance for water quality monitoring. However, because of the above and other obstacles, developing effective monitoring programmes is still a significant test facing state and territory jurisdictions and land and waterway managers across Australia.

12.3 Response

New South Wales has given consideration to how a comprehensive approach, which is consistent with the NWQMS, may be developed and applied to achieve improved and well-targeted water quality improvement programmes. It has done so by developing a state-wide Monitoring Evaluation and Reporting (MER) strategy. Within the MER strategy the current indicators of estuarine condition are micro-algal and macro-algal abundance, fish assemblages and macrophyte abundance. These are supported by water clarity (turbidity, secchi) and salinity. Two process indicators are currently in development: derived primary production and trophic status of sediments. Pressure indicators are also reported. An interpretive model suite known as CERAT has been developed to provide the links between catchment pressure and algal and seagrass abundance in estuaries—for more information, see the [Ozcoasts website](#).

The current indicators of river condition are macro-invertebrate assemblages, fish assemblages and hydraulic stress. These are supported by trends in turbidity, temperature and salinity. Habitat quality and riparian and aquatic vegetation indicators are current ideas that are in development. Pressure indicators are also reported.

12.4 Benefits

Effective monitoring can make a real difference to management decisions by showing what is needed to guide actions and investment to improve or sustain water quality. The approach outlined below was followed when selecting indicators for the condition of two of the main themes in the MER strategy—estuaries and rivers. In the future, this more robust and comprehensive monitoring and evaluation system will enable changes in natural resource condition to be better tracked and understood. Improved management and investment decisions will also be derived from the evaluation of the data.

12.5 Lessons learned

Water quality improvement processes can be complex. Once the initial substantial gains are made by effectively tackling point sources of pollution (such as by upgrading sewage treatment plants) then, in many cases, further gains may take many years to obtain. The comprehensive and structured approach used by New South Wales to develop its monitoring strategy has wide transferability for adaptive use in other jurisdictions. Based on the New South Wales experience, some logical and sequential steps that need to be considered when developing a monitoring programme are described below.

The first step is to conceptualise the system. First, identify physical links and flow paths within the system. Then qualitatively link pressures, stressors and condition of the system. ‘Pressures’ are human-induced changes and are the level at which we can take management action. Some examples of pressures include land use, entrance change (in estuary systems), water extraction, riparian clearing and population density. ‘Stressors’ are the physical and chemical consequences of changes in pressure and include pollutant (for example, nutrient) loads, altered tidal prism and river flows, salinity, altered trophic structure, turbidity, physical damage/disturbance and carbon flow. The ecological ‘condition’ of the system results from the actions of stressors on the ecological components. Identification of linkages by this process focuses attention on developing indicators that are appropriate to the system.

The second step is to define the area of interest and, if it is physically heterogeneous, establish management zones. These zones will be based on the physical links established in step 1 above, and need to be spatially discrete, physically logical and relatively homogeneous internally. The use of management zones enables large and diverse systems to be subdivided into more manageable units based on their characteristics (biological, physical, chemical et cetera) and condition. It also enables the community and waterway managers to determine appropriate levels of ‘ecosystem protection’ consistent with the *Australian and New Zealand guidelines for fresh and marine water quality* (2000) within each zone. This then allows the setting of water quality objectives (WQOs) with appropriate condition targets and potential management actions in order to maintain or improve the situation within a zone.

The third step is to select the indicators to monitor. In selecting indicators, some of the underlying principles include the following:

- Separate out drivers/pressures, stressors and condition.
- Responses of indicators to pressures and stressors should be well understood and predictable.
- Indicators of changes in pressure and stressors can provide short-term data.

- A mixture of indicators of both function and abundance is required for condition.
- A referential system is required, which will involve identifying a reference condition.
- It should be possible to make a link between the indicator value and the pressure status.

When selecting indicators of condition, it is important to carefully apply the NWQMS guidelines. The guidelines advocate the use of biological indicators for ecological health or condition. Most definitions of ecological health include concepts of biological community composition ('what's there') and function (how ecological processes such as recruitment, herbivory, primary production, trophic structure et cetera are operating). Indicators of ecological condition should reflect both these concepts and, if possible, some major structural elements (habitat availability, salinity regime, flow regime, et cetera) as well.

A cursory application of the guidelines may result in a focus on water quality indicators for assessing condition or outcomes. However, there are several dangers with this. Firstly, water quality monitoring, in and of itself, is essentially monitoring stressors, so it rarely tells us what we really want to know about ecological health or condition. This is because, in many situations, the links between stressors and outcomes may be tenuous at best. Secondly, if the indicator behaviour is not tested, we do not know what stressors the condition indicators are responding to; therefore, we are unable to take effective management action.

To interpret indicators, we need to obtain either data from control sites or reference or target values for the indicators. The development of targets needs to be based on a transparent and reproducible process. Ideally, targets should be treated as trigger values, and the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000* recommends the 80th percentile of reference data as one way to define targets.

Increasingly, models are being shown to be very useful as part of management planning and decision making. Models can help define appropriate management zones by graphically showing the characteristics of different parts of the system. Models also have a role in helping to make the links between ecological condition and management interventions as well as informing where management will be most effective and indicating the potential costs involved. Finally, models can also be an immensely useful educational tool to indicate the potential scale of change that is required to improve environmental quality.

It is important to embrace the NWQMS as comprehensively as possible and at an early stage so that resulting monitoring frameworks are better able to deliver the information required for planning and decision making. Further, the use of models at each step in the water quality monitoring process may be very worthwhile as an aid to understanding and also as an education tool.

13 An integrated approach to coastal catchment issues in the Peel–Harvey system

Table 16 Peel–Harvey system coastal catchment management—summary

NWQMS focus:	Integrated catchment planning and action and nutrient reduction
Lead organisation:	Environment Protection Authority (WA)
Contact:	08 6467 5600
Partner organisations:	Peel Harvey Catchment Council, Peel Development Commission, Department of Environment and Conservation (WA), Department of Water and Department of Agriculture and Food (WA) and the Australian Government Department of Sustainability, Environment, Water, Population and Communities

13.1 Place

The Peel Inlet – Harvey estuarine system is located 75 kilometres south of Perth in the south-west of Western Australia. The system consists of two shallow lagoons—the Peel Inlet and the Harvey Estuary. These lagoons are fed by three major rivers—the Murray, Serpentine and Harvey. This area is part of the Peel–Yalgorup system—a wetland of international significance. It is the most important area for waterbirds in south-western Australia and supports a wide variety of other species.

It is also heavily used for recreational boating and fishing; it is the largest professional and amateur estuarine fishery in Western Australia.

13.2 Challenge

As a result of nutrient input over many years, there are large stores of phosphorus in the soils and sediments of the coastal portion of the Peel–Harvey catchment, which has had a significant impact on water quality. After decades of declining water quality and subsequent severe algal blooms in the estuary, a Peel Inlet and Harvey Estuary Management Strategy was announced and approved in January 1989. The strategy outlined actions such as catchment management measures, nuisance macro-algae harvesting and monitoring to assess the effectiveness of the management interventions. An Environmental Protection Authority (EPA) report in 2003 found that components of the strategy had been successful but that poor water quality was still an issue in the rivers and some lakes. Significant action was still required to reduce the phosphorus input to the waterways in particular, as this is one of the key drivers of algal blooms.

13.3 Response

Under the Australian Government’s Coastal Catchments Initiative, the Peel–Harvey system was identified as a water quality hotspot of national importance, as it is a high-value aquatic ecosystem where pollution needed to be reduced. A Water Quality Improvement Plan (WQIP) for the Rivers and Estuary of the Peel–Harvey System—Phosphorus Management, released in 2008, formed the principal response to the significant challenges being faced.

WQIPs are one way that the NWQMS is implemented, and this WQIP was developed collaboratively by the Western Australian and Australian governments. The development of the WQIP was assisted by the output of seven projects: a decision support system for water quality protection; support system for phosphorus reduction decisions; water quality monitoring programme; water-sensitive urban design; regulation and licensing review; targeted assistance to intensive agricultural industries; and stock exclusion from catchment waterways.

13.4 Results

The completed WQIP recommended the implementation of a comprehensive suite of management measures to reduce phosphorus discharges to estuarine waters (see Box 4) and correspondingly reduce the incidents of excessive and often toxic algal blooms. The holistic approach, which built upon current catchment management activities, and research was necessary because of the wide array of phosphorus sources. The WQIP also recommended the development of a framework to enhance water quality through land-use planning processes for the Peel–Harvey catchment.

The WQIP identified the environmental values (EVs) of the area, the water quality objectives (WQOs) that will protect these EVs and the amount of phosphorus loads in the system. The WQIP also identified a set of management measures and control actions to achieve and maintain those EVs and WQOs. The WQO for the estuary was for median loadings of total phosphorus to estuarine waters to be less than 75 tonnes per annum in an average year. Component median loads were calculated for the Serpentine, Murray and Harvey rivers, which drain into the estuary. The WQO to be achieved within each of these catchment waterways was set so that water quality at the draining point (outlet) met a median winter concentration value of 0.1 mg/L for total phosphorus. These concentrations and resultant total phosphorus loads in the estuary would act to significantly limit the likelihood of algal blooms.

To further support the integrated implementation of the WQIP, scientific investigations were recommended into altered nutrient and sediment loads and transport, changes in channel morphology, floodplains and wetlands, and impacts on riparian and aquatic habitats and fauna.

13.5 Benefits

Achieving a reduction in phosphorus levels will take some time due to the large stores of phosphorus in the soils and sediments that continue to leach into waterways.

However, the WQIP has provided an excellent framework and process through which to work. In particular, the development of targets, the use of modelling and the integrated consideration of environmental flows have each yielded benefits as outlined below:

- *Modelling and target setting*—predictive modelling tools were used to calculate load reduction targets for 48 outlets across 17 reporting catchments based on current climatic and land-use conditions. These load targets represented the load reduction required in each catchment in order to meet the WQO of 0.1 mg/L for total phosphorus at each reporting catchment outlet. Beneficial understanding and direction was obtained by using the large-scale catchment model called LASCAM to assess the impact of management decisions on water and nutrient delivery from the catchment to the estuary.
- *Environmental flows*—the WQIP was also designed to achieve environmental flow objectives. These sought to maintain natural flow variability; protect wetlands and floodplains by mimicking natural inundation and drying patterns; and minimise the effect of dams on water quality by

mimicking natural frequency, duration and seasonal flow. Real benefits will arise from the WQIP by incorporating the concept of Environmental Water Requirements. These are descriptions of the water regimes necessary to achieve the environmental flow objective by either maintaining or restoring ecological processes and/or protecting the defined environmental values consistent with the ARMCANZ/ANZECC *National principles for the provision of water for ecosystems* (1996). While river flow objectives are being properly defined, water resource managers are focusing on maintaining the existing flow regimes in the Serpentine, Murray and Harvey catchments.

Box 4 Recommended management measures and control actions

The key measures and actions to reduce phosphorus inputs entering the estuary include:

- improved management of agricultural land, including using low water soluble fertilisers and bauxite residues as soil amendments, perennial pastures to better utilise phosphorus and improved management of irrigation systems
- improved management of urban land, including low water soluble fertilisers and bauxite residues as soil amendments, and incorporating water-sensitive design in the environmental and planning referrals and approvals processes
- improved management of urban and rural effluent, including retrofitting existing septic tanks to reduce nutrient sources, full connection to sewerage and excluding stock from catchment waterways
- licensing of agricultural nutrient discharges to the estuary
- protection and revegetation of wetlands and waterways by maintaining a buffer of riparian vegetation and excluding stock from these areas, and reforestation of agricultural areas
- modification to drainage management practices to reduce in-channel sediment movement as opportunities arise
- continued research into and investigation of best management practices available for nutrient reduction in the rural and urban landscapes of the Peel–Harvey catchment to improve understanding of how nutrient reduction measures are performing and inform adaptive management
- implementation of a monitoring and reporting programme (at a range of scales) of suitable indicators and targets to allow evaluation of the efficacy of the plan
- identifying and addressing barriers to the uptake of best management practices within the catchment and measures that may increase the rate of uptake
- fostering of community partnerships to promote awareness of and collectively manage water quality issues.

13.6 Lessons learned

A focused and effective series of integrated actions has been generated from the improved understanding of pollution and catchment processes from the WQIP and its supporting projects. Some key lessons learned from the Peel–Harvey experience are widely transferable to other Australian regions. Holistic implementation of the NWQMS can be achieved by:

- initially focusing on key issues and what is achievable within an overall integrated approach
- setting load reduction targets and using catchment models
- using intermediate targets to achieve longer-term goals of water quality improvement

- developing Environmental Flows Objectives.

The successful implementation of the WQIP has been identified as a key component in meeting long-term WQOs for phosphorus reduction in the Peel–Harvey.

Coordinated implementation of catchment management initiatives is essential, as is an appropriately structured, resourced and accountable mechanism in the Peel region to integrate these activities with land-use planning processes. The WQIP recommends the establishment of an effective governance framework, including the establishment of a management body to oversee implementation of the WQIP’s recommendations.

The final and perhaps the most important lesson learned from the Peel–Harvey is the realisation that significant improvements in water quality may take 20 to 50 years or even longer to achieve. Maintaining engagement of community, government and industry stakeholders via continuing activities and programmes is pivotal to success, as is regular monitoring and reporting through annual reviews and community report cards. While reductions in loads may appear within, say, a 10-year time scale, this story of success from the Peel–Harvey clearly demonstrates that long-term commitment and resourcing is required and that implementing the NWQMS is quite a journey.

However, when this journey is guided by the principles, policies and processes of the NWQMS, it is well capable of progressively attaining local and regional water quality.

14 National guidelines

The national guidelines that form the National Water Quality Management Strategy (NWQMS) have been endorsed and released by the former Environment Protection and Heritage Council, the Natural Resource Management Ministerial Council, the Australian Health Ministers' Conference and/or the National Health and Medical Research Council.

These national guidelines are technical papers providing nationally agreed guidance on many aspects of the water cycle, including ambient and drinking water quality, recreational water management, monitoring and reporting, groundwater protection, rural land and water issues, urban stormwater, sewerage systems effluent management for specific industries, and water recycling. The NWQMS guidelines are not mandatory and provide guidance to governments and communities on the sustainable management of the nation's water resources. The full set of NWQMS documents is available on the [NWQMS website](#).

15 References and further reading

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